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DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

ACCIDENT COSTS AND SAFETY DIVIDENDS

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BY

D. HARRINGTON

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DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

ACCIDENT COSTS AND SAFETY DIVIDENDS[1]

By D. Harrington[2]

INTRODUCTION

In general, mining is carried on underground, that is, in confined places where it is difficult to obtain adequate lighting and frequently in rock strata requiring much care to prevent caving. Moreover, explosives must be used in mining with the numerous hazards associated with them, and some mines give off explosive or irrespirable gases; also, machinery must be used, usually under conditions much more hazardous than on the surface. These and many other considerations cause mining to be probably the most hazardous occupation in which large numbers of our fellow countrymen are employed.

Prevention of accidents in the mining industry is far more complicated than in surface industrial work, even of the more hazardous types, because the different elements that enter into possible accident occurrence are ascertained more readily above ground and suitable action can be taken against them; moreover, errors in connection with prevention of accidents in surface industrial work usually affect only one or, possibly, a few persons, while in mines one human error may readily cause an explosion or other untoward occurrence resulting in the death of scores or even hundreds of persons.

This difficulty in the prevention of accidents in and around mines is well-known, and most countries and States have regulations to guard the safety and, to a much smaller extent, the health of workers in mining and allied industries. In general, the State laws and regulations regarding the welfare of mine workers are merely a skeletonized outline of some more or less fundamental minimum requirements and are far too general to do much more than suggest some procedure which may or may not be safe or healthful. Most of them are grotesquely out-of-date as applied to present-day conditions, and none of them is adequate to protect life, limb, health, or property.

Unquestionably, there is great need for a closer correlation of the laws and regulations of the various States with regard to safety in the mining and allied industries, and while mining conditions vary far too much for a standardized mine safety law applicable to all of the States, on the other hand there are numerous standard and fairly fundamental safety provisions which apply to all mines and which should be embodied in the mining codes of all States. Undoubtedly, these standardized safety requirements would be opposed by a considerable part of the industry, but the ultimate effect would be beneficial to the owners, workers, and the general public.

For many years progressive mining companies in the United States have not been satisfied to operate only within the meager safety requirements of the State laws or regulations and have adopted additional and far more effective safety procedure of their own, although complying also with the State laws and regulations. As a result of this forward-looking policy, many of these companies have made astonishing progress in the reduction of accidents. This

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is true of bituminous-coal and anthracite mines; metal mines; nonmetallic mineral mines; coking plants; milling, smelting, and metallurgical establishments; and the various activities in connection with the production and processing of petroleum. Some mines have worked 25 or more years without a fatal accident; others have worked with a considerable number of men a year or more without a lost-time accident. One surface mining operation produced upward of 75,000,000 tons of rock without a fatality, another underground mine produced over 15,000,000 tons of ore without a fatality, and numerous individuals have worked 50 or more years in mines without having sustained any accident which would prevent their working at their own job on the next regular shift.

That considerable progress has been made in the prevention of accidents in the mines of the United States is not generally known, and a few figures will doubtless be illuminating. At various times in the past most persons remember having read headlines in the daily press calling attention to some terrible mining disaster; fortunately, affairs of this kind are now few and far between.

ACKNOWLEDGMENTS

The material in this paper has been taken from various sources, some of which are given in footnote references. Some of the data were assembled by associate engineer C. W. Owings, Pittsburgh Experiment Station, Bureau of Mines.

ACCIDENT OCCURRENCE IN MINING

During the 5-year period 1906-10, inclusive, there were 84 major disasters (those in which 5 or more lives were lost) in United States coal mines. The total number of fatalities from coal-mine gas and dust explosions, major and minor, for the 5 years aggregated 2,388 or 477.6 per year. The shocking loss of life in the frequent coal-mine disasters so roused the country that the Federal Government was urged to act. This resulted in the establishment of the United States Bureau of Mines in 1910. The Bureau pioneered in research into causes and methods of accident prevention in the mining and allied industries; this and other activities of the Bureau of Mines in cooperation with State mining departments, mine operators, and others have been so effective that in 1933 there was only 1 major explosion in the coal mines of the United States and in 1934 only 2. During the 24 years existence of the Bureau of Mines there has apparently been a saving of about 7,300 lives from gas and dust explosions alone, or an average of more than 300 per year; that is, this number of lives would have been lost in mine disasters alone if the fatality rate from explosions that existed before the Bureau was established had been permitted to continue. During the past 6 or 7 years, rock-dusting, one of numerous measures recommended by the Bureau of Mines to check or prevent mine explosions, unquestionably has been instrumental in saving at least 200 lives annually and also preventing property damage amounting to several million dollars a year.

During the 5-year period 1906-10, inclusive, 13,288 persons were killed in the coal mines of the United States from all causes (including explosions), an average of 2,658 per year, and the fatality rate for this 5-year period was 5.89 persons killed per million tons of coal produced. In 1931 this figure was 3.31, in 1932 it was 3.36, and in 1933 it was 2.78; preliminary figures for 1934 indicate that the fatality rate was 2.77, with the probability that the 1934 figure will ultimately be about 2.85, or next to the lowest rate in the history of coal mining in this country, the rate of 2.78 in 1933 being the lowest or best rate so far recorded.

If the 5.89 fatality rate for the 5-year period 1906-10, inclusive, had continued to the first of January 1935, the lives lost would have been 25,500 more than the number re-

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corded. Therefore, during the 24 years an average annual saving of life of nearly 1,100 persons is indicated. Similar figures are not available on prevention of nonfatal accidents, but it is estimated that there are about 50 nonfatal accidents to 1 fatality; therefore, at least 50,000 nonfatal accidents per year have also been prevented during the past 24 years in American coal mines alone, the total number for the 24 years aggregating the enormous sum of more than 1,200,000.

Downward Trend in Occurrence of Accidents in Mining.- The years 1930 to 1934, inclusive, have been decidedly encouraging to the proponents of health and safety in the mining and allied industries, notwithstanding the numerous vicissitudes that have been thrust upon not only health and safety workers but also upon all other persons engaged in these industries as well as upon the public at large. For the first time since health and safety have been actively fostered in the mines of the United States, those engaged in the work have been able to see not only trends toward better things but actually to find those trends substantiated by undeniable facts and figures showing the utter fallacy of the more or less universally held belief that mining is so inherently unsafe that efforts to operate mines safely are futile.

Table 1, taken from data in Bureau of Mines publications, gives illuminating information on the occurrence of fatal and nonfatal accidents in metal mines and quarries and on fatalities in coal mines.

TABLE 1.- Accident rates in metal mines, quarries, and coal mines in the United States, 1911-33 inclusive

Period	Metal mines, killed and injured per thousand 300-day workers (calculated)	Quarries, killed and injured per thousand 300-day workers (calculated)	Coal mines, killed per million tons of coal produced
1911-15	202.38	91.58	4.76
1916-20	245.04	162.39	3.86
Average 1911-20, Incl.	224.36	123.84	4.27
1921-25, Incl.	276.27	175.22	3.96
1926-30, Incl.	213.22	140.77	3.75
1926	248.48	162.15	3.83
1927	224.64	164.55	3.73
1928	208.11	131.41	3.78
1929	203.14	129.79	3.59
1930	170.78	109.76	3.84
1931	142.09	106.04	3.31
1932	138.46	97.33	3.36
1933	155.13	97.59	2.78
1934			[1]2.77

[1]Tentative and likely to be raised to about 2.85.

In this table the fatal plus nonfatal accident rates per thousand 300-day workers in metal mines and quarries are given by various periods from 1911 to 1933, inclusive; as similar figures are not at hand for coal mines (nonfatal accident data being unavailable, except since 1930) fatality rates per million tons of coal produced are given since they are the most definite data procurable on accidents in coal mining.

It will be noted that the fatal plus nonfatal accident rate per thousand 300-day workers in metal mines varied relatively little in the 5-year periods from 1911 to 1930, the rate

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for the 5-year period 1926-30, inclusive, being somewhat higher than for the 5-year period 1911-15, inclusive. A study of the lower part of the table, giving the rates annually from 1926 to 1933, inclusive, indicates that the first real break in the metal-mining rate came in 1930 when for the first time it fell well below 200. After the break the improvement continued, the rate for 1931 being lower than that for 1930 and the rate for 1932 being slightly lower than that for 1931. The 1934 rate is not yet available.

In quarrying the break from a high accident rate to a definitely lower one came in 1930, and since then every succeeding year has shown a slightly lower rate than its predecessor, indicating that the industry has accident-prevention work well in hand, although the rate for 1933 was slightly higher than that for 1932.

In coal mines the fatality rate per million tons of coal produced remained obstinately high after the considerable lowering of the rate from 4.76 for the 5-year period 1911-15, inclusive, to the much more favorable rate of 3.86 for the succeeding 5-year period 1916-20, inclusive. The rate hovered around or was slightly under 3.85 until 1931 when the lowest rate known until that year (3.31) was achieved. The 1932 rate of 3.36 failed to equal the excellent record of 1931 but was the next lowest rate so far; the rate for 1933 was 2.78, or by all odds the lowest or best rate in the history of coal mining in the United States. Preliminary figures for 1934 give a rate of 2.77, but when final data are assembled this is likely to be raised to about 2.85, which is far lower than in any other year in the history of coal mining except 1933.

The table indicates that accident rates in metal mining began to be lowered definitely in 1930 and that additional progress was made in 1931 and 1932, although there was a slight recession in 1933, and although final figures are not available for 1934 (and won't be for several months) the rate for 1934 probably will not be as favorable as that for 1932. In fact, 1932 seems likely to hold the all-time safety record in metal mining in the United States, at least until the metal mines are again on a normal, steady producing basis; however, so many metal mines, especially those producing iron ore, have been able to operate almost without accidents that there is ample reason to believe that accident rates will again drop and probably drop fast when normalcy is reached in metal mining.

Table 1 shows that the definite downward trend in occurrence of quarry accidents began as far back as 1928 and that, as in other branches of mining, safety in quarrying suffered a slight set-back in 1933. However, the exceptionally fine accident performances of a number of quarries in the United States, notably those operated by cement companies, many of which have operated several years without a lost-time accident, indicate that quarry accident rates will probably sustain a definite fall extending over several years.

Coal-mining data in table 1 are restricted to fatalities on a tonnage basis, as these are the fullest and most reliable data available; the Bureau did not attempt to secure information on nonfatal coal-mine accidents prior to 1930. The table shows that definite progress in reducing the coal-mine fatality rate was lacking until 1931 and that in 1932, while the safety record was relatively good, it was somewhat poorer than that in 1931. However, in 1933, notwithstanding numerous influences which might be expected to increase rather than decrease the coal-mine fatality rate, the rate was actually by far the best or lowest in the history of coal mining in the United States; and while the rate in 1934 will probably ultimately be slightly higher than that in 1933, there is no question that it will be much lower than that of any other year except 1933.

It is thus seen that the definite downward trend in accident occurrence in mining started in 1930 or 1931. The reasons for optimism as to the future of accident occurrence in the mining and allied industries, notwithstanding the fact that the record for 1934 was undoubtedly poorer than that for 1933 or 1932, will be given later.

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ACCIDENT COSTS

Obviously, all right-minded people should look upon safety, whether in mining or in any other walk of life, primarily from the humanitarian standpoint, as the prevention of loss of life and limb with its attendant suffering is a goal well worth almost any expendable effort. Unfortunately, however, human nature is so constituted that constant and universal application of high-minded principles to the prosaic features of industrial work is not and probably never will be obtainable. It is now evident to those most experienced in accident-prevention work that safety is likely to be achieved and "safety dividends" declared only when the officials in charge of mining or of other types of industrial projects actively support and encourage safety programs, and generally, although not invariably, the attitude of mining company executives can be interpreted in only one manner - safety expenditures must show a dollars-and-cents return on the investment. Although this is rather cold-blooded, perhaps it is logical, as industry to continue in existence under our present economic system must return a profit; hence, if safety is to be given any appreciable attention, it must also show a profit. A superintendent of a coal mine, in which accidents from falls of roof and coal were occurring with undue regularity, was informed by a trained safety engineer that unquestionably the accidents could be reduced greatly if more timbers were used; the reply was that additional timber would cost extra, therefore this accident-prevention plan was given scant consideration even though probably not only accident occurrence but also accident cost would have been reduced if the plan or a good modification of it had been adopted. A similar viewpoint is held by many superintendents, general superintendents, general managers, vice presidents, and presidents of mining companies, especially when these officials reside a considerable distance from the mine. Safety directors and safety workers in immediate contact with the mine usually consider saving in human life and suffering sufficient justification for spending money on safety, even if the company should receive no immediate dollars-and-cents return for such expenditures. To the surprise of most safety workers, a rigid accounting frequently reveals that so-called philanthropic expenditures for health and safety in mining have also paid large dividends in money.

Comparison of Accident Costs.- The figures published by the compensation commissions of the various States do not conform to any set type or standard, and it is practically impossible to correlate the various compensation costs. In some States the cost includes hospital and medical expense, while in others only the compensation outlay is given, and compensation for any given type of injury varies from State to State. The cost of compensation alone is given for seven States[3] in table 1. Arizona has one of the most drastic compensation laws in the United States, and while this is reflected in high costs in individual cases the progressive mining companies have been able to overcome the supposed handicap by intensive safety work, and their compensation costs per $100 of pay roll have been held definitely low. The cost of temporary disabilities in mining ranges from $15 in New York to $108 for bituminous mines in Pennsylvania. Permanent partial disabilities range in cost from $506 for mining in Washington (in 1930) to $3,686 for disabilities of more than 18 months in Arizona. Permanent total disabilities have the highest average cost, ranging from $6,526

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3 Ash, S. H., Accident Experience and Cost of Accidents in Washington Metal Mines and Quarries: Tech. Paper 514, Bureau of Mines, 1932, 35 pp.

New York Department of Labor, Cost of Compensated Cases: Special Bull. 178.

Ott, Lee, Nineteenth Annual Report of State Compensation Commissioner, West Virginia, for Year Ending June 30, 1932.

Herbert, C. A., A Review of Coal-mine Fatalities in Indiana During the Fiscal Year October 1, 1931 to September 30, 1932: Inf. Circ. 6746, Bureau of Mines, 1933, 16 pp.

Annual Report of Coal Section of Pennsylvania Compensation Rating and Inspection Bureau (mimeographed).

Fene, W. J., Accident Experience and Cost in Pennsylvania Anthracite and Bituminous Mines, 1926-30: Inf. Circ. 6618, Bureau of Mines, 1932, 29 pp.

Confidential unpublished data.

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for bituminous mines in Pennsylvania to $15,484 for mining in Arizona; one California total disability finally resulted in a fatality 15 years later, and the hospitalization costs alone (including services of doctors, nurses, etc.) aggregated more than $43,000. The cost of fatalities ranges from $3,193 in West Virginia to $6,900 (for quarrying) in New York.

TABLE 2.- Compensation cost of accidents in seven States

State	Period	Average cost for each injury in dollars				
		Temporary disability	Permanent partial disability	Permanent total disability	Death	Average compensable disability
Arizona:						
Mining	1926 - 29	$77	[1]$642 [2]$3,686	$15,484	$6,521	$372
Indiana:						
Coal mining	1930					304
Do.	1931					334
New York:						
Mining	1930	15	633		6,603	415
Quarrying	1930	18	999		6,900	649
All industrial	1930					321
Pennsylvania:						
Bituminous	1927 - 31	108	2,429	6,526	3,786	312
Anthracite	1927 - 31	107	2,084	6,829	4,572	387
Tennessee:						
13 coal mines	1926 - 31					250
West Virginia:						
Industrial	1913 - 32		945	6,891	3,193	94
Washington:						
Mining	1924 - 30	38	830	8,624	5,348	244
Do.	1930	47	506	9,334	6,664	376

[1]Disability of 18 months or less.
[2]Disability of more than 18 months.
NOTE.- The data for this table were taken from various sources. (See footnote 3.)

The average cost of compensable injuries ranges from $94 for coal mining in West Virginia to $649 for quarrying in New York. The average cost of industrial injuries in New York in 1930 was $321, which agrees closely with an average estimate of $300 frequently made for compensable nonfatal industrial accidents in general. The average cost of nonfatal coal-mine accidents in Pennsylvania from 1916 to 1930 was $165. Numerous fatalities occur in mining in which the victim has no dependents, and the only direct cost, at least in some States, is that of a funeral; the cost of funerals in Pennsylvania coal mines averaged $103 from 1916 to 1930, and in West Virginia the funeral cost has been fixed at $150. It is believed that $100 is a conservative average for the cost of nonfatal accidents in mining in the United States, inasmuch as many nondisabling injuries in mining entail an expense of $10 or less.

The cost of nonfatal lost-time accidents has been placed at $300 for a year's experience of 30 petroleum companies with about 55,000 employees, and it was also stated that the cost of nonfatal lost-time accidents in the petroleum industry amounts to about $12 per year for every employee in the industry.

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An insurance company gives the compensation and medical cost of nonfatal lost-time accidents in the construction industry as $378 for a recent 2-year period having a comparatively large number of cases. In his paper "Profits Through Reduction of Accidents" in the Mining Congress Journal of September 1932, J. T. Ryan places the cost of each nonfatal lost-time (compensable) accident at $168, which represents the experience of the Pennsylvania Department of Labor and Industry covering 1,169,820 cases since 1916. Recent 1934-35 accident experience on a large tunneling project in the western part of the United States gives the average cost of nonfatal lost-time injuries as $328; this report also stated that the man who sustained a lost-time injury received on an average $173 in compensation and sacrificed $608 in wages. In another part of the United States a large coal-mining company gave figures indicating that for a certain period employees were paid $1,217 as compensation for injuries sustained, and during this period of disability the lost wages aggregated slightly over $3,200.

In a study of a considerable number of no-lost-time injuries in 1934, a large tunnel-driving project found that for every such injury reported the first-aid and medical attention cost the employer $9. In a similar study of several thousand no-lost-time injuries a few years ago, a company mining coal, iron ore, and limestone and smelting and fabricating iron and steel found the average cost of these injuries to the operating company to be $4, which was approximately the daily wage at that time.

Maximum Costs of Fatalities.- The maximum compensation benefits that may be obtained under the various State compensation laws[4] are tabulated in table 3. Where the law specifies death or remarriage, a life of 20 years has been used. Where the workman leaves dependents compensation for death ranges from $3,000 in New Hampshire and South Dakota to as high as $50,000 (under some conditions) in Arizona. Death awards for a person who leaves no dependents range from $100 to $6,600; 5 States provide a payment to a special or rehabilitation fund, and 4 States provide payment to a second injury fund. Burial fees range from $75 to $200, the average being around $136.

Permanent total disabilities generally entail the greatest compensation cost, ranging from $3,000 to around or even over $50,000; temporary total disabilities range from $832 to $20,800, and these injuries also probably entail the maximum amount of grief and suffering in the long run. Partial disabilities have the lowest cost, ranging from $1,500 to $20,800. Medical and surgical costs are unlimited in a number of States, but estimated average costs range from $100 to $800.

The case of Jack Schaub, a California workman, attracted wide-spread interest and publicity; he was injured and became paralyzed from the hips down on December 13, 1917 and died on August 17, 1932. Hospital expenses were $24,943.94, nursing services $14,435.00, and doctor fees $3,848.46, or a total cost for the accident of $43,227.40. He lived for nearly 15 years after having sustained the injury and, of course, his sufferings during that time are not measurable in dollars and cents.

Medical and Hospital Cost.- Compensation is only part of the direct cost of accidents. Medical, hospital, and burial costs average from one fourth to one half as much as the compensation cost. During the 5-year period 1924 to 1928, inclusive, the compensation cost in California for 3,182 accidents, including 96 fatal accidents, was given as $1,054,580; medical aid was $505,142, or approximately 48 percent of the compensation cost and 32 percent of the total direct cost. Compensation costs for a group of mines in Arizona, during the 4 years ended December 31, 1930, were $464,336.17, and medical aid amounted to $86,227.50, or about 18 1/2 percent of the compensation and nearly 16 percent of the total cost. In 13 coal

4 U.S. Bureau of Labor Statistics, Department of Labor, Workmen's Compensation Legislation of the United States and Canada: July 1926.

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TABLE 3.- Maximum compensation benefits, by States

State	Death			Total disability		Partial disability	Medical aid
	Dependents	No dependents	Burial	Permanent	Temporary		
Alabama	$5,000	$100	$100	$5,000	[1]$4,500	[1]$4,500	$100
Arizona	[2]30,000	[3]1,000	150	[4]50,000	[5]6,500	[6]6,500	[7]300
California	5,000	150	150	[8]5,000	5,000	5,000	[7]300
Colorado	3,750	125	125	[4]12,480	3,750	3,120	300
Georgia	5,000	100	100	5,000	5,000	[1]3,600	100
Idaho	[9]4,800	[3]1,200	200	[9]6,400	[9]6,400	[10]2,400	[7]300
Illinois	4,550	[11]450	150	[12]7,904	3,750	[12]7,904	[7]300
Indiana	5,000	100	100	5,000	5,000	[1]9,000	[7]300
Iowa	[1]4,500	250	150	[9]6,000	[1]4,500	[7]4,500	100
Kansas	4,000	150	150	[12]7,488	[12]7,488	[12]7,488	100
Kentucky	4,000	175	75	6,000	6,000	[1]6,000	200
Maine	4,000	200	200	6,000	6,000	5,400	100
Maryland	5,000	125	125	5,000	3,750	3,750	500
Massachusetts	10,400	[11]250	100	4,500	4,500	4,500	[7]200
Michigan	[1]5,400	200	200	9,000	9,000	[13]9,000	[7]200
Minnesota	7,500	[11]350	150	10,000	10,000	[1]6,000	[7]200
Missouri	[1]6,250	250	150	[1]6,000	[9]8,000	[14]2,000	250
Montana	[9]6,000	125	150	[15]7,500	[1]6,000	[10]2,250	500
Nebraska	[16]5,250	150	150	[1]4,500	[1]4,500	[1]4,500	[7]200
Nevada	[2]19,200	150	150	[4]8,640	7,200	[17]2,400	[7]500
New Hampshire	3,000	100	100	[1]4,500	[1]4,500	[1]4,500	[7]100
New Jersey	[1]6,000	250	150	[9]8,000	[4]6,000	[15]10,000	100
New Mexico	[1]9,000	225	75	[18]6,240	[18]6,240	[7]18,750	150
New York	[2]36,000	[3]1,200	200	[4]26,000	5,000	4,000	[7]300
North Dakota	[2]15,000	150	150	[2]15,000	[7]20,800	[7]20,800	[7]300
Ohio	6,500	150	150	[4]5,850	3,750	3,750	200
Oklahoma	.....	.....	.....	[15]9,000	[1]5,400	3,000	100
Oregon	[2]31,200	100	100	[4]36,400	[7]18,200	2,400	250
Pennsylvania	[1]7,200	150	100	6,500	6,500	[1]4,500	100
Rhode Island	[1]4,200	200	200	5,000	5,000	[1]3,000	200
South Dakota	3,000	150	150	3,000	[19]4,650	[19]4,650	200
Tennessee	[9]6,400	100	100	5,000	[1]4,800	[1]4,800	100
Texas	[20]7,200	100	100	[21]8,020	[21]8,020	[1]6,000	[7]200
Utah	5,000	[11]1,150	100	[4]16,650	5,000	5,000	500
Vermont	3,500	100	100	4,000	4,000	[22]2,600	200
Virginia	4,500	150	100	4,500	4,500	[1]3,600	[7]200
Washington	[2]13,200	100	100	[4]9,600	[4]9,600	3,000	[7]200
West Virginia	[2]7,200	150	150	[4]16,640	[23]832	[4]16,640	800
Wisconsin	6,000	[3]6,600	200	[24]19,500	[25]6,000	[7]19,500	[7]200
Wyoming	3,600	150	150	8,000	8,000	1,500	300

(See page 9 for footnotes)

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FOOTNOTES FOR TABLE 3

[1]300 weeks.
[2]Death or remarriage, estimated 20 years.
[3]Payment to rehabilitation or special fund.
[4]Life, estimated 20 years.
[5]100 months.
[6]60 months.
[7]Estimated.
[8]240 weeks.
[9]400 weeks.
[10]150 weeks.
[11]Payment to second injury fund.
[12]8 years.
[13]500 weeks.
[14]100 weeks.
[15]500 weeks.
[16]350 weeks.
[17]60 weeks.
[18]520 weeks.
[19]6 years.
[20]360 weeks.
[21]401 weeks.
[22]260 weeks.
[23]52 weeks.
[24]1,000 weeks.
[25]4 years.

NOTE.- Oklahoma makes no provision for deaths.

This table was taken from data in U.S. Bureau of Labor Statistics, Bull. 423.

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mines in Tennessee compensation cost $146,087 and medical aid $46,817, or the medical cost was about 32 percent of the compensation cost and more than 24 percent of the total cost. From 1925 to 1929, inclusive, medical aid in Pennsylvania[5] cost 65 1/2 percent of the compensation for temporary disabling injuries and about 7 1/2 percent of the compensation for deaths in bituminous mines.

One coal-mining company reduced its accident occurrence materially, and the direct cost of accidents dropped from about 7.5 cents per ton to 1.5 cents per ton; in producing about 1,030,000 tons of coal with a direct cost of accidents of about 1.5 cents per ton, this mine had $3,955 charged to hospitalization and $11,830 to compensation, hence the hospitalization (doctor plus hospital charge) was about 33 percent of the cost of compensation and about 25 percent of the total direct cost of accidents.

In a paper in the Mining Congress Journal of September 1932, J. T. Ryan sets the "medical attention and hospitalization" cost of producing coal at 0.5 cent per ton besides the compensation cost of 5 cents per ton.

The cost of infections is more serious than is usually believed. In a bulletin issued to its employees in 1933, the Cleveland Cliffs Iron Co. had the following interesting information:

Infections are Often Serious

Based on insurance and compensation figures the following estimates have been made:

1. About 250,000 cases of infected wounds develop every year.
2. Insurance companies pay from 40 to 60 percent of their compensation for infected wounds.
3. The lost time for a case of infection averages 18 weeks longer in disability than of a noninfected case.
4. There is a total annually of about $104,227,500 from infected wounds in industry; the total loss of time involved is 4,458,333 weeks, or the equal of 85,737 years.
5. About 90 percent of all industrial injuries occur to the hands and fingers.

It is probable that most of such cases are only scratches or small cuts to start with. First aid or prompt treatment by the doctor are by no means a needless bother; the chances are all the other way.

COST OF INJURIES BY PARTS OF BODY AFFECTED

The cost of injuries varies in general according to the part of the body affected. The cost fluctuation is due largely to the ease or difficulty of healing the wound which governs the medical aid and hospital costs. If the injury causes the loss of a part of the body, compensation laws usually govern the compensation paid. The costs of personal injuries for a coal-mining company[6] which gives considerable attention to safety are segregated in table 4 according to the type of injury.

5 Information submitted by letter to author. Sources given in footnote 3.

6 Name of company withheld by request.

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TABLE 4.- Cost of personal injuries of a coal company for 4 years

Nature of injury	Number of injuries	Injury payments	Average cost per injury
Head and face	109	$1,766.29	$16.20
Eye	124	1,975.84	15.93
Arm	64	479.81	7.50
Leg	88	5,514.10	62.66
Hand and finger	232	6,119.53	26.38
Foot and toe	109	2,971.91	27.27
Body	93	1,734.13	18.65
Fatal	6	20,775.00	3,462 50
Total	825	41,336.61	

The 4-year cost to this coal company of injuries to its employees ranges from $62.66 for leg injuries to $7.50 for arm injuries; the cost of fatal accidents averaged $3,462.50 each. The average cost of all accidents, including fatalities, was $50.10, and nonfatal injuries averaged $25.11; evidently the most costly parts of the body injured in this mine are the legs, hands, fingers, feet, and toes.

The coal-mine section of the Pennsylvania Compensation Rating and Inspection Bureau, in a comprehensive study and analysis of coal-mine accident costs over a certain period, shows that the average cost of injuries in the anthracite mines was $415, of which amount compensation comprised $337 and medical aid $78; and the average cost of injuries in bituminous mines was $321, the compensation costing $257 and medical aid $64.

The compensation and medical-aid costs of major permanent disabilities, minor permanent disabilities, temporary disabilities, and noncompensable injuries are listed in table 5, by parts of body affected, for coal mines of Pennsylvania from 1925-29, inclusive.

The cost of major permanent injuries for the period 1925-29, inclusive, averaged $2,351 in anthracite mines and $2,378 in bituminous mines; the loss of an arm cost $3,622 and $3,800 in anthracite and bituminous mines, respectively; the loss of a hand cost $2,724 and $2,754, the loss of a leg $3,685 and $3,485, the loss of a foot $2,331 and $2,525, and the loss of an eye $2,137 and $2,892 for anthracite and bituminous mines, respectively. The medical cost for major permanent disabilities averaged $196 for anthracite mines and $232 for bituminous mines; for minor permanent injuries the medical cost was $72 and $80, respectively. The cost of major permanent disabilities in Pennsylvania in 1925-29, inclusive, was slightly more than half as much as that of fatalities, the total fatality cost being $4,140,969 and the major permanent disabilities costing $2,719,951. Temporary disabilities cost practically the same as fatalities - $4,142,161. The total cost of nonfatal injuries was $8,859,093, or more than twice the cost of fatal injuries. Loss of eyes constituted the greatest loss, averaging $468,639; loss of feet, totaling $265,952, ranked second; loss of legs, $255,588, was the third largest cost; loss of hands, costing $205,381, and loss of arms, totaling $124,328, were fourth and fifth, respectively, in the cost of major permanent disabilities.

Accidents in 10 mines in the Southern Appalachian coal field[7] cost $130,000 in 5 years, including hospitalization, X-rays, and lawsuits. The average cost was 2.5 cents per ton of coal mined. The cost of 35 permanent partial disabilities, entailing a loss of 16,583 days, was $33,079.66; 628 temporary total disabilities, resulting in 21,390 days lost time, cost $25,343.98, or an average of $40.36 each.

7 Source of information confidential.

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TABLE 5.- Loss analysis, by parts of body injured, in Pennsylvania coal mines 1925 to 1929, converted to the 1928 level[1]

Anthracite Mines

Severity of injury	Average cost	Average compensation	Average medical cost
Major permanent	$2,351	$2,155	$196
Loss of arm	3,622	3,418	204
Loss of hand	2,724	2,536	189
Loss of leg	3,685	3,375	310
Loss of foot	2,331	2,134	198
Loss of eye	2,137	2,012	125
Disfigurement	609	520	89
Other permanent	3,158	2,895	263
Indeterminate	1,945	1,700	245
Minor permanent	477	405	72
Temporary	115	71	44

Bituminous Mines

Major permanent	2,378	2,146	232
Loss of arm	3,800	3,522	278
Loss of hand	2,754	2,544	210
Loss of leg	3,485	3,186	298
Loss of foot	2,525	2,245	281
Loss of eye	2,033	1,892	142
Disfigurement	2,892	2,591	301
Other permanent	1,887	1,667	220
Minor permanent	509	420	80
Temporary	115	74	40

[1]From the 1929 report of the coal-mine section of the Pennsylvania Compensation Rating Bureau.

The parts of the body affected, and the average cost of the accidents, in these 10 mines were as follows: 47 hand injuries, $25.56; 164 injured fingers, $37.84; 24 injured arms, $26.52; 37 injured eyes, $19.33; 39 injured heads, $33.34; 29 strained backs, $52.58, 74 injured legs, $82.87; 64 injured feet, exclusive of injured toes, $33.86; 29 injured ankles, $41.78; 40 injured toes, $28.44; 10 hernias, $85.71; and 73 other body injuries, $37.71. These figures are not confined to loss of a member or members as were the Pennsylvania costs, and the relative figures are therefore different. In the opinion of the man in charge of the compensation, the injuries were the direct result of carelessness except in one or two instances.

The December 1934 Monthly News Letter of the public utilities section of the National Safety Council contained the following interesting item under the caption "What Price Fractures:"

Fractures are costly both to the employee and the employer. They are not only costly, but they cause excruciating and unnecessary pain.

From a recent analysis covering 162 fracture cases which occurred during 1933, as compiled by a large public utility, the average loss of time for a frac-

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ture was 172 days. The following tend to bring out the 'highspots' of the analysis:

	Days
Average disability for a fracture of any part of the head	2,269
Average disability for a fracture of any part of the body exclusive of the head, upper and lower extremities	311
Average disability for a fracture of the leg	136
Average disability for a fracture of the arm	57
Average disability for a fracture of the foot	34
Average disability for a fracture of the toe	14
Average disability for a fracture of the finger	3

The average medical costs for the various types of fractures were:

Head	- $150.00
Body	- 334.01
Leg	- 221.63
Arm	- 230.78
Foot	- 108.94
Toe	- 39.35
Finger	- 45.48

While the preceding data refer only to accidents of a certain type in connection with a "large public utility" rather than a mining organization, they give information of value as to days lost in connection with certain types of accidents to various parts of the body and the average medical cost of treating these accidents.

The mean minimum compensation payment to injured persons in mining States of the United States[8] is about $6.00 a week, and the mean maximum is about $15.00 per week. The scale of time losses for weighting industrial disabilities used by the Bureau of Mines classes a fatality, permanent total disability, and loss of sight in both eyes as total disabilities and assigns 6,000 days as the time lost. On this basis the minimum cost of the loss of both eyes would average $5,143, and the maximum cost would average $12,857. Loss of arm above the elbow or loss of leg above the knee is classed as 75-percent disability, hence the minimum cost would be $3,857 and the maximum cost $9,643. The loss of an arm at or below the elbow would cost $3,086 to $7,714; loss of a hand, leg below the knee, and hearing of both ears constitute 50 percent disability and would cost $2,572 to $6,429. The loss of the great toe would cost $257 to $643, and the loss of any other toe carries no specified compensation. The loss of a finger costs the same as a great toe, and the loss of a thumb costs twice this amount. Thus it is seen that the loss of a member of the body, or permanent impairment of it, is likely to be an expensive accident.

The United States Bureau of Mines analyzed 8,017 temporary injuries causing an aggregate loss of 114,665 days lost time, or an average of 14 days per injury. In this somewhat limited study it was found that the mean minimum cost of temporary disabilities throughout the United States averaged $12, and the maximum averaged $30 for compensation alone. The average head and face injury caused a loss of 9 days, resulting in a cost of $7.72 to $19.30. Eye injuries averaged $6.85 for one eye and $10.30 for two eyes as a minimum and $13.72 and $25.78 as a maximum. The average lost time from injuries to the upper extremities was 14 days, entailing an average cost of $12 to $30. The cost ranged from $8.56 to $21.41 for a wrist injury and from $48 to $120 for an injured humerus. Finger and thumb injuries caused

8 See footnote 4.

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an average loss of 14 days, the lowest average being 12 days for the ring finger and the highest being 15 days for a little finger, the minimum cost averaging $10.29 to $12.85 and the maximum cost $25.70 to $32.15. The average injury to the trunk caused a loss of 16 days and cost $13.70 to $34.25. Lower extremities, when injured, averaged 18 days lost time at a cost of $15.43 to $38.60. Knee injuries cost from $12.85 to $32.15, and injuries to the kneecap averaged $32.60 to $83.50. Toe injuries, averaging 13 days lost time, cost from $11.15 to $27.85. Medical cost in the above cases was not considered; however, for minor injuries the medical cost is likely to be practically equivalent to the compensation cost.

COST OF NONFATAL ACCIDENTS BY CAUSES

The cost and analysis of 95 nonfatal accidents in a coal mine,[9] covering a 2-year period, are given in table 6. This analysis does not include all accidents, but it shows a definite trend in accident costs for nonfatal injuries. A comparison of the number of man-hours lost and the cost of settlement indicates that in this mine nonfatal injuries cost nearly 91 cents per hour of lost time.

TABLE 6.- A critical analysis of accidents in a coal mine over approximately a 2-year period

Number of cases	Cause	Number of man-hours lost	Settlement expense
1	Employee not instructed at all	16	$33.42
5	Instructions not enforced	152	370.82
2	Instructions incomplete	192	60.61
7	Employee not skillful	208	247.19
3	Employee ignorant	409	211.82
6	Employee used poor judgment	234	344.72
10	Disobedience of rules	692	1,590.95
12	Interference by others	1,399 1/2	1,124.07
1	Attention distracted	162	214.70
11	Inattention	2,004	2,134.42
7	Taking chances	1,056	695.71
1	Short cuts	128	38.42
3	Haste	114	116.95
3	Employee sluggish or fatigued mentally	272	72.45
1	Employee excited or angry	128	26.02
4	Employee physically defective	341	103.29
1	Employee fatigued physically	34	23.56
1	Danger points inadequately guarded	1,408	765.90
1	Untidy or otherwise dangerous passages or work spaces	120	109.28
1	Clearances insufficient for safe work	24	12.84
1	Improper tools used	16	45.12
6	Method of doing work improperly planned	616	810.00
1	Unsafe lay-out of plant	176	32.98
6	Proper personal safety equipment not available	256	234.06
	Total	10,157 1/2	9,189.53

9 Name of company withheld by request.

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DIRECT COST OF ACCIDENTS

Direct costs are ascertained fairly readily insofar as the employer is concerned; they comprise the compensation paid to the injured man, the medical and surgical fees, and the hospital fees and expenses and usually are tangible deductions from the funds of the employer. Wages lost by the injured employee or other dollars-and-cents costs to him do not affect directly the operating cost of a mine or quarry and are not included in the usual acceptance of the "direct" cost of accidents in or to industry. However, the injured worker usually is given in compensation very much less money than he would have earned if he had continued at work uninjured, in addition to immeasurable losses in pain, misery, and other hardships, mental and physical, to him and possibly to many others connected with him as relatives, friends, or otherwise. Of course, the dollars-and-cents loss to the worker and his family in a fatality or a permanent total disability cannot be calculated.

Washington may be taken as representative of States in which direct costs of coal-mine accidents are high due to various factors and conditions. In 1927 compensation and medical costs averaged 11.0 cents per ton; in 1928, 7.9 cents per ton; and in 1929, 9.0 cents per ton. The 1913 to 1929 average was 8.05 cents per ton, according to S. H. Ash in Bureau of Mines Information Circular 6529; this circular shows that the cost per $100 of pay roll was $3.74 from 1913 to 1929, although in 1929 the cost was $4.63. The compensation and medical cost of accidents in Washington metal mines and quarries (Bureau of Mines Technical Paper 514) during the 7-year period 1924-30 averaged $3.36 per $100 of pay roll, ranging from $1.69 in 1924 to $5.87 in 1929.

Accident costs for medical aid and compensation in 8 metal-mining States, according to a report of a special California Senate committee which in 1931 investigated mining compensation-insurance rates, averaged for California $5.50 per $100 of pay roll, for Idaho $2.77 and for New Mexico, $2.33, the figures for these 3 States being based on the period 1924-28; for Colorado, $3.68, in 1923-27; for Montana, $5.28, in 1924-28; for New York, $6.46, and for Utah, $3.99, in 1923-27; and for Nevada, $3.05, in 1929-30. The average direct cost of compensation and medical aid for the above 8 States and Washington was $4.05 per $100 of pay roll.

Medical and compensation cost in Pennsylvania from 1926-30, inclusive,[10] was 3.19 cents per ton for coal insured by the State fund and 3.22 cents per ton for bituminous coal from all mines. This cost ranged from 2.62 cents per ton in 1927 to 3.44 cents per ton in 1928. The average cost for the bituminous mines of Pennsylvania for the 5-year period 1926-30 was 2.93 cents per ton; and for the anthracite mines of Pennsylvania the average cost was 5.43 cents per ton, ranging from 3.43 cents in 1926 to 7.26 cents per ton in 1930. The added direct accident cost of 3, 4, or more cents per ton of coal mined may be the difference between operating at a loss or profit, and it must be remembered that the direct cost is only a relatively small part of the total cost of accidents.

The direct cost of accidents in and around the coal mines of the United States probably averaged at least 4 or 5 cents a ton of coal mined with wages and contract rates as of 1931 and 1932 and about 5 1/2 to 6 cents in 1933 and 1934. A similar comparison cannot be made for metal and nonmetallic mines and tunnels, but the cost per $100 of pay roll in 1933 and 1934 may be estimated to range from a low of $3.40 to $4.00 to as high as $15.00 for metal mines and perhaps as high as $35.00 for tunneling.

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10 Fene, W. J., Acident Experience and Costs in Pennsylvania Anthracite and Bituminous Mines, 1926-30: Inf. Circ. 6618, Bureau of Mines, 1932, 29 pp.

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INDIRECT COST OF ACCIDENTS

Until the past few years most mine officials have avoided rather carefully discussions or the compiling or giving of data on the dollars-and-cents costs of accidents, and this has been decidedly detrimental to progress in safety in mining. At present some mine managements fail to understand the direct loss caused by accidents, and relatively few of them study or realize what is meant by the indirect cost of accidents to the management or the enormous losses involved. Statistical studies have shown that when an accident occurs and afterward there are numerous losses to the employer in addition to the compensation and medical costs in connection with the injured man or men. At the time of and after an accident considerable time is lost by other workmen in assisting the injured workman, in stopping work to view the place where the accident occurred and to discuss the incident with fellow workmen, or in clearing away the wreckage to mine or plant due to the accident. In some mining localities all men stop work if a man is fatally injured; the production thus lost may have a decided effect on the profits. Many accidents occur in and around mines without injury to persons but with heavy loss to the company. An extreme example of a noninjury accident[11] shows how much one accident may cost. A workman, on coming out of a mine, stopped to warn the foreman that some bad roof on a haulage road was "working." The foreman said he did not have time to attend to it then but might at some other time. The roof fell and caused the closing of a section in which coal production was about 150 tons a day; this was in 1920, and the company was selling its coal for about $10.00 a ton, the profit being about $6.00 a ton. Failure of the foreman to try to prevent this accident cost the company at least $900.00, and it was only good luck that prevented one or more workmen from being caught by the fall. Other indirect costs are the expense of the supervisors in making an investigation of the accident, damage to equipment, cost of hiring new men to replace the injured employee, and many others, any one of which may be decidedly costly.

The cost of employing new men to take the place of those who have been injured may be heavy. A large coal-mining company, after making a thorough study of the cost of hiring a man, estimated that it cost at least $25 to hire and put to work the least skilled employee and as much as $2,000 or even $3,000 to employ a new foreman or superintendent.

The indirect cost to the employer of accidents in dollars and cents has been estimated to be at least four times the direct cost, hence the cost of compensation and hospitalization is thought to be only about one fifth of the total cost to the employer. On this basis the indirect cost of coal-mine accidents in Washington would amount to 32.20 cents per ton from 1913-29 and in Pennsylvania bituminous mines to 11.72 cents per ton from 1926-30. For anthracite mines the indirect cost would have been 21.72 cents per ton during the same period.

An excellent analysis of the factors likely to enter into the indirect cost of accidents is given in the October 1934 Monthly News Letter of the wood products section of the National Safety Council, as follows:

> These costs are conservatively estimated to be not less than FOUR times the amount paid in compensation, medical, and hospital expense. Moreover these items are NOT INSURABLE.
>
> 1-Time lost from production by employee as a result of injury.
>
> 2-Time lost from production by other employees who stop work (a) Out of curiosity, (b) to assist injured, (c) out of sympathy, and (d) because of nervous shock.
>
> 3-Temporary slowing down of production in department because (a) Employees gather in groups to talk about accident, and (b) thoughts of the acci-

11 Source of information confidential.

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dent continue to divert their attention from their work. (This may also lead to another accident, spoiled material, or damage to equipment.)

4-Time lost from production by foremen, supervisors, or other executives to (a) aid injured employee, (b) investigate cause of accident, (c) arrange for injured employee's production to be continued by some other employee, (d) select, train, or break in new employee to replace injured one, (e) prepare accident reports for employer, insurance carrier, and State, and (f) attend hearings before State Industrial Accident Commission.

5-Time of first-aid attendant and hospital department staff (when not paid by insurance).

6-Spoilage and waste of material caused by accidents.

7-Damage to machine, tools, building, or other property.

8-Losses due to interference of accidents with production, such as failure to fill orders on time, loss of bonuses, payments of forfeits, cancellation of orders, loss of customer goodwill, etc.

9-Loss of profit on productivity of employees affected by the accident and on machines temporarily idle.

10-Loss in putting injured employee back on pay roll and paying full wages when injured is not fully recovered and is unable to earn the wages paid.

11-Loss through inferior productive effort due to inability (where high accident rates prevail) to attract and hold high-grade workers. Inferior workers waste more and cause more accidents.

Probably the most convincing exposition of the far-reaching consequences of the indirect cost of accidents is found in a paper entitled "The Cost of Industrial Accidents to the State, the Employer, and the Man", by H. M. Heinrich, of the Travelers Insurance Co., read before the International Association of Industrial Accident Boards and Commissions in Wilmington, Del., on September 23, 1930. Mining people who have not read this excellent address should by all means do so.

One of the serious factors in the indirect or hidden cost of accidents is the expense to the employer for the noncompensable accidents, large numbers of which are likely to occur in any mine or mining plant. A few years ago a large-capacity steel company with coal, iron ore, limestone, and other mines, as well as blast-furnaces and fabricating plants, studied several thousand accidents in which the injured person lost no pay time and the company paid no compensation. The accidents included slight cuts on finger or hand, a sliver in a finger, etc., and the injured person continued with his day's work. It was determined that the average cost of every such accident to the company was $4.00, which happened to be the average daily wage at the time. The October 1934 Monthly News Letter of the Wood Products Section of the National Safety Council had the following analysis of the cost factors entering into accidents of this type:

To 1 accident causing injury and loss of productive time of employee, there are, in industry, 29 accidents that result in slight injuries without loss of time (except for first aid) and 300 NO-INJURY ACCIDENTS.

These 300 NO-INJURY ACCIDENTS cause:

1-Loss of time of workers, foremen, superintendents, plant engineers, and others in making repairs, getting things going again, doing a job over, etc.

2-Damage to machinery and equipment.

3-Waste of materials and supplies.

4-Interference with production schedules, delays, waiting for new machine part after break-down, etc., and increased hazards from rushing the work afterwards.

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In the coal and metal mines of the United States scores of fires occur annually in which no life is lost and no workers are injured. Very few of these fires are controlled and extinguished successfully with an expenditure of less than $100, and some of them cost over $100,000. There also occur annually numerous falls of material, wrecks of haulage equipment, and similar accidents in all types of mines, as well as explosions of gas or dust in our coal mines, without injury or death to persons but with heavy damage to the mine or plant and resultant expense in restoring normal operating conditions; in some cases these no-injury accidents cost thousands of dollars.

When all of the phases which enter into the indirect cost of accidents (including those in which injury or death occurs as well as those devoid of personal injuries) are considered one is forced to believe that the indirect cost must be several times (and probably at least four times, as is usually given) the direct cost of accidents. Therefore, it behooves the mine management to try to its utmost to avoid the occurrence of all kinds of accidents in and around mines. While this may seem Utopian and impossible of fulfillment, the results now being obtained by many mining companies with well-directed safety effort give ample promise that the goal may be reached approximately if not absolutely.

TOTAL COST OF ACCIDENTS IN MINING

It appears that the direct cost of accidents in coal mining is at least 4 cents (and probably nearer 5 cents per ton of coal produced) and that their direct cost in metal and other types of mining is around or over $5.00 per $100.00 of pay roll. If the indirect cost is 4 times the direct cost, as is now thought to be approximately correct, then the total cost (direct plus indirect) of accidents in coal mining in the United States is around 20 cents or possibly 25 cents per ton, and the total cost of accidents in metal and nonmetallic mineral mining is around $25.00 per $100.00 of pay roll.

Probably 20 cents per ton is not 1 cent too high for the total cost of accidents in coal mining, and certainly 15 cents per ton is far too low. Twenty-five dollars per $100.00 of pay roll seems high for the total cost of accidents in metal and nonmetallic mineral mining, but $18.00 or $20.00 is conservatively low. These figures are 10 or more percent of the mine cost of production, therefore, at least 10 percent of the mine cost of producing our mineral products, coal, ore, or nonmetallic mineral products, is brought about through the occurrence of accidents.

INSURANCE COSTS

Insurance companies have found that the loss ratio for casualty insurance in mining exceeds the premiums, in some cases averaging as much as 1.22. For that reason many of the large insurance companies have withdrawn from taking risks in the mining industry, and generally where such insurance is granted the insurer must give other types of insurance to the insurance company so that the latter may try to "break even" on the compensation and attendant losses. The various States have practically been forced to offer insurance to mining companies, and apparently the rates are high. The mining premium rates per $100 of pay roll in 1930[12] were as follows: California, $10.54; Arizona, $7.79; Colorado, $5.03; Idaho, $4.15; New Mexico, $4.57; Nevada, $5.10; Utah, $6.00; and Washington, $3.36.

Safety effort and the use of safety equipment in mining operations are recognized in some States by allowing a credit for the adoption of safety measures and equipment as well as

12 Ash, S. H., Accident Experience and Cost of Accidents at Washington Metal Mines and Quarries: Tech. Paper 514, Bureau of Mines, 1932, 35 pp.

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for past safety accomplishment. In others, no credit is allowed. Unquestionably this is unfair and places a premium on carelessness and incompetence in safety effort and performance; it also handicaps very seriously (and in many instances the handicap is so nearly intolerable that well-intentioned mining companies are forced out of business) the mining organization that tries to operate safely or that actually does operate safely. In many cases, the premium is so high that some companies that have given safety careful consideration have become self-insurers as an added means of securing SAFETY DIVIDENDS and have had the satisfaction of reaping these dividends in full measure.

A metal mine paying $3.10 compensation per $100 of pay roll came under the supervision of a mining man who had established very good safety records in his previous places of employment. He had the company "take over" its own compensation obligations, and instituted an accident-prevention campaign. In less than a year the rate was reduced to considerably less than $1.00 per $100 of pay roll. This seems miraculous, but this man had accomplished essentially the same feat in handling other mining operations, hence knew that "it could be done."

President C. W. Crane, of the St. Joseph Lead Co., read a paper on safety before the mining section of the National Safety Council in Cleveland, Ohio, on October 4, 1934; a paragraph from a discussion of Crane's paper in Coal Age of November 1934 reads as follows:

> Every company should keep a balance account of the cost of the safety department and of its accomplishment. The 6-year average of cost of compensation of the St. Joseph Lead Co., a self-insurer, is $1.66 per $100 of pay roll. The safety work costs 73 cents per $100 of pay roll, this covering the salaries and expenses of the safety department. The cost, therefore, has been $2.39. The company would have had to pay $4.66 had it purchased compensation, and the average cost of such compensation for the mines of the State was $8.66. Actual costs for compensation should be known to every foreman, and the direct saving from his individual efforts should be always in his mind.

REDUCING COSTS THROUGH SAFETY ACCOMPLISHMENT

Examples of the monetary savings possible through the adoption of a complete safety-organization plan and institution of a determined, well-thought-out safety campaign are easily found, and a few will be given. In 1925 one mine[13] with an average of 125 employees had 3 fatalities, 28 compensable disabling injuries, and 17 noncompensable disabling injuries, resulting in 18,986 days lost time; in 1926 it had 1 fatal, 1 permanent total, 1 permanent partial, 38 compensable, and 29 noncompensable disabling injuries, causing 14,991 days lost time; in 1927 it had 3 fatal accidents and 11 compensable and 15 noncompensable disabling injuries, causing a total loss of 18,705 days. In October 1927, through suggestions of a representative of the Safety Division of the United States Bureau of Mines, a safety-organization plan was instituted, and a vigorous safety campaign was put into and kept in effect. No deaths have occurred, so far as known, since January 1, 1928; moreover, no permanent disabilities are known to have occurred since that date. In 1928 there were 2 disabling accidents, causing 1,820 days lost time, of which 1 was compensable. In 1929, 4 compensable and 7 noncompensable disabling injuries resulted in 144 days lost time. During 1930, 5 compensable and 2 noncompensable disabling accidents caused 308 days lost time. On January 8, 1931 two miners received crushed fingers from a rock rolling and catching their fingers against the side of the car that they were pushing; from then to May 25, 1933 there were no disabling

13 Name of company withheld by request.

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accidents in the mine. A surface employee was injured on July 17, 1931, and no further disabling injuries occurred in the plant until March 28, 1933.

The company was insured through a casualty insurance company, but after inaugurating the safety campaign the company became self-insuring. The cost of accidents in 1927 was $40,-181.63. After the safety program was put into effect, the cost of accidents was reduced to $5,859.32 in 1928, $2,769.29 in 1929, $3,720.00 in 1930, $934.29 in 1931, $86.92 in 1932, and $601.16 in 1933. If the 1927 rate had been in effect from 1928 to 1933, accidents would have cost $241,089.78, hence the savings in 6 years may be estimated at $227,118.80. This company undeniably made a substantial saving by assuming full responsibility for accident occurrence and then trying to eliminate accident occurrence.

Safety is or at least should be an operating problem, and executives who have adopted it as such and have given intelligent, well-directed effort to the work have returned safety dividends to their companies. Safety workers thoroughly believe that supervision and discipline are the keynotes to accident reduction or elimination, although they recognize that under some conditions both may be handicapped through influences beyond control of those in charge of industrial operations. A large coal-mining company[14] changed from hand-loading to mechanical-loading methods, and although such changes have resulted frequently in higher accident costs the increased supervision and the close attention given to safety resulted in a lowering of the injuries from 8.9 per thousand man-shifts during 2 1/3 years with hand loading to 5.0 per thousand man-shifts during 1 2/3 years with mechanical loading. The accident costs (direct costs only) decreased from 5.5 cents per ton with hand-loading to 3.2 cents per ton with mechanical loading; the saving amounted to $29,203.33, or at the rate of $17,522 a year. It is doubtful if any other department of the company, even by the closest figuring, could have effected a proportionate saving, especially as the "dividend" was obtained with little or no additional outlay of money, supervision being the governing factor.

In a statement in 1934, James Berry of the Ohio Department of Mines is quoted as follows:

> Prior to 1933 mine accidents in this southern section (of Ohio) cost 5.6 cents per ton for each ton of coal mined there. Following the organization of safety department in that locality, accidents now cost approximately 1.7 cents per ton for each ton taken out of the ground.

The above statement, taken from the Hanna Coal News of September 1934, indicates that these Ohio coal mines, by going systematically into safety work, cut the direct cost from 5.6 cents to 1.7 cents, or 3.9 cents per ton. If the direct cost of accidents is only one fifth of the total cost, this safety work has reduced the cost of coal production by 5 times 3.9 cents, or 19.5 cents per ton, certainly a worthwhile saving.

A coal-mining company operating several small mines paid in compensation nearly $18,000 in 1929 and over $22,000 in 1930. In 1930 Bureau of Mines 100-percent first-aid training was given, and a Bureau of Mines engineer made safety inspections and reports on the mines; this plus other safety efforts of the operating company reduced the compensation to $15,000 in 1931, $7,000 in 1932, and $3,500 in 1933, and it is understood that the 1934 record is good. The severity rate was 51.0 in 1931 and only 4.8 in 1933.

An outstanding record was made by another mechanized coal mine.[15] A safety engineer was hired in the spring of 1930. The accident cost was high during the first 6 months of the year, averaging 11 cents per ton of coal mined; the cost for the entire year 1930 was 8.0 cents per ton, and the cost per lost-time accident was $260. In 1931 the average cost was reduced to 1.2 cents per ton, and the cost per lost-time accident was $140; during 1932, 1933, and 1934 the costs were held below 1 cent per ton.

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14 Name of company withheld by request.

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The difference in cost of accidents in 1930 compared with 1933 and 1934 is 7.3 cents per ton of coal mined. The accomplishment is the more outstanding because no great financial expenditures were made in bringing about the material reduction of injuries; the responsibility for the safety of the men was placed directly on the shoulders of the supervisory officials, and these officials and the safety engineer have impartially enforced the few safety rules promulgated. When the safety work was started the largest proportion of accidents were from falls of roof, and most of the fatalities were caused by such falls; when reasoning with officials had no apparent effect, a warning was issued that if a man was killed by a fall of roof the officials responsible would be discharged and would not be allowed to act again in a supervisory capacity. Shortly afterwards a man was killed by a roof fall while laying track; the investigation disclosed that within an hour preceding the accident three supervisors had entered the place and had failed to detect the loose roof; they were discharged. Major injuries, such as broken backs, from falls of roof continued, and a ruling was made that if a major injury occurred from fall of roof, the supervisory official would be discharged. Since these rules went into effect fatalities and major injuries from roof falls have been decreased so materially that they appear almost to have been eliminated. The reduction of 7.3 cents per ton of coal in cost of accidents from 1930 to 1933 and 1934 represents much if not all of the difference between profit and loss at the present-day cost of producing coal, and the profit in this case is due largely to increased supervision and discipline with relatively little additional financial outlay for safety.

The chief factor in the reduction of industrial accidents frequently is the dual system of exercising adequate supervision and strict but just discipline; however, this is only part of the main system or organization for "putting over" safety in mining. The safety program of every mining company should include a complete safety organization plan to coordinate safety efforts; safety to be even measurably effective must start at the head of the organization, and the active operating officials must be whole-heartedly behind the promotion of safety and must give a fair amount of their personal time and attention to the work to assure its success. The safety work should be under the direction of a competent safety director or engineer who should devote his entire time to safety promotion. A more or less standard organization has been developed for the mining industry, comprising a chairman, who should be the manager, superintendent, or other ranking official of the company; a secretary, who should preferably be the safety director or engineer; and a membership including all other supervisory officials of the company and representatives of each type of workmen employed. This committee should formulate safety rules, make various kinds of safety inspections and reports, and perform other functions which may lead to the improvement of health and safety in and around the mine.

The mine safety organization should be supplemented by a general safety organization, such as the Holmes Safety Association sponsored by the United States Bureau of Mines, in which all employees, including officials, surface, and underground workers and store and office force, etc., are members. Meetings should be held at least monthly. The Holmes chapter is a medium for assembling all employees in or around the mine monthly and educating them in safe practices as well as calling their attention to unsafe practices.

A large metal mine had an accident cost of $300,000 in 1924, but through safety efforts the cost was reduced to $59,000 in 1930, or a saving in accidents that year of $241,000. Another large metal-mining company decreased lost-time accidents from 1.047 per thousand man-shifts in 1924 to 0.040 lost-time accident per thousand man-shifts in 1930. Still another large metal-mining company operated for 7 years and 3 months without a fatal accident, working a total of 1,192,436 man-shifts. The average yearly cost of compensation per $100 of pay roll in a group of metal mines in a State with high unit payments to the injured in case of accident was $3.04 in 1926, $2.89 in 1927, $2.49 in 1928, and $2.00 in 1929; the saving

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in the cost of compensation to these self-insuring mines which entered actively into accident-prevention work was approximately $500,000 in 1929 compared with 1926.

By putting into effect an intensive safety organization and campaign, a Pennsylvania bituminous-coal-mining company in 1 year saved $60,000, or 3 cents per ton of coal mined. The organization of six chapters and the Tenth Bituminous District Council of the Holmes Safety Association in Pennsylvania unquestionably resulted in direct savings to the coal companies; the production of coal by the council members was 5,500,000 tons in 1930 and 4,500,000 tons in 1931. Fatal accidents decreased from 12 to 5; lost-time accidents of 60 days or more decreased from 104 to 77; and accidents involving less than 60 days lost time decreased from 1,007 to 707 in the same period. The increased safety was attributed to the functioning of the Holmes chapters and the activities of the council. After organization of the chapters four of the member mines reduced their accident cost more than half.

The Dehue mine[16] in West Virginia, according to published data, had an exceptionally unfavorable safety record from 1917 to 1927. During this period 36 fatal accidents occurred, an average of 3.3 per year. In 1928, $28,180 in compensation was paid; by 1930, compensation costs had decreased to $12,044; and from January 1 to November 20, 1931 compensation amounted to only $662. The direct cost of accidents in 1928 was 4.6 cents per ton of coal mined, and for 10 1/2 months in 1931 the average cost was 0.25 cent per ton, a reduction of 4.35 cents per ton in 2 years. The estimated indirect cost in 1928 was $112,700, or 18.6 cents per ton; in 1931, for 10 1/2 months, the indirect cost was $2,651, or 1.3 cents per ton. During the 1931 period, $11,050 in direct cost was saved, and the saving in indirect cost was $44,457, or 17.3 cents per ton of coal mined. In 1928 the accident-frequency rate was 185.34, and in 1931 it was 2.77; the accident severity rate was 21.73 in 1928 and 0.822 in 1931. Only one lost-time accident occurred in 1931 to November 20. This record was achieved through the launching of a sincere safety drive based on a definite safety program in which all employees from the ranking operating official to the lowest paid laborer showed keen interest and cooperated fully.

The coal industry is a good example of what safety has done for mining in the United States. In the 5-year period 1906-10 inclusive there were 84 major explosions in the coal mines of the United States, or 17 per year, and the total fatalities from explosions in the coal mines of the United States were 2,388, or 478 per year. As against this ghastly record, there was only 1 major explosion in the coal mines of the United States in 1933, costing 7 lives; there were only 2 major disasters in the coal mines of the United States in 1934, a fire with 5 deaths and an explosion with 17 deaths; and to April 1, 1935 only 1 major explosion occurred in a coal mine, and it cost 13 lives. Surely this is an extra dividend for safety in the operation of coal mines, whether it is figured on a humanitarian basis or on a cold-blooded dollars-and-cents basis, and there is absolutely no doubt that long-continued, well-directed safety work has accomplished this almost miraculous result. Much of the credit is due to the extensive use of permissible explosives, permissible electric equipment, and permissible electric cap lamps in the more dangerous mines. Rock-dusting has unquestionably aided in saving at least 200 lives annually for the past 10 years by preventing widespread explosions through their propagation by coal dust.

The training of approximately 900,000 persons in first-aid in the mining and allied industries in the past 25 years by the field forces of the Bureau of Mines has been responsible for saving at least 200 lives annually for the past 10 years and for instilling safety-consciousness in mine workers, with consequent prevention of at least 10,000 injuries every year (some of which very probably would have resulted in fatalities).

16 Agee, E. B., Cost of Mine Accidents: Min. Cong. Jour., vol. 18, no. 1, January 1932, p. 32.

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This first-aid training and other mine safety activities have reduced fatalities in the coal mines of the United States from 2,658 per year for the period 1906-10, inclusive (or the enormous total of 13,288 for those 5 years), to 1,013 in 1933 and about 1,150 in 1934; moreover, the annual tonnages produced in these years did not differ materially. The fatality rate in the coal mines of the United States per million tons produced in 1933 was only 2.78, or less than half of the 5.89 rate for the 1906-10 period; this is the lowest rate by far in the history of coal mining in the United States. There is reason to believe that safety effort of various kinds, exerted as a result of the admittedly bad fatal-accident record of the coal mines of the United States from 1906-10, inclusive, has resulted in the prevention of at least 1,000 fatal accidents and from 50,000 to 100,000 nonfatal accidents annually since 1910. Surely, safety has produced dividends of the highest and most valuable type by this performance.

COST OF SAFETY WORK

The cost of maintaining adequate safety in a mining property is considerable but certainly is not excessive, and with equal certainty the ultimate cost of neglecting safety in and around mines is heavy not only on the operating company and its employees but also on the entire community.

The explosion in a Welsh coal mine in September 1934 in which 265 lives were lost is a good example of the vast losses which accrue to mine workers and their families, the mine owners, the community at large, and the Government, possibly to others, when certain types of accidents occur. Because of fires caused by the explosion most of the 265 dead persons were sealed in the mine a few days after the disaster occurred, and the mine remained sealed until March 1, 1935. Approximately 1,500 workers were thrown out of employment by the closing of this mine, and to aid these unemployed persons as well as the dependents of those who were killed in the disaster a public subscription was taken which aggregated nearly $3,000,000; the operating company has had very great losses in compensation and other similar payments in the 265 deaths, in the enormous damage done to the mine, in the loss of several months' business, and in numerous other ways. Moreover, who can even begin to calculate the vast amount of suffering and misery which the disaster has occasioned among the relatives and friends of the dead persons, as well as the economic losses to these people, to the local tradesmen, and to others due to these deaths and the sealing of the mine for several months, possibly its permanent abandonment? There is reason for the belief that this one accident will ultimately cost at least $5,000,000 and possibly as much as $10,000,000 in money and much more than that in misery and suffering. Probably this amount of money would cover nicely the entire cost of adequate safety work in all of the coal mines of Great Britain for several years.

From 15 to 17 cents per ton seems reasonable as the total present-day cost of coal-mine accidents; inquiries also have been made as to the cost of preventing accidents, but definite data are not readily obtainable as far too many conflicting elements enter into the cost of conducting coal mines to segregate effectively all of those features which pertain to safety. Logically, safety enters very definitely into supervision, ventilation, haulage, timbering, blasting, etc., as well as rock-dusting, first aid, safety organization, safety meetings, and other similar items; however, such items as supervision, ventilation, timbering, haulage, and blasting are an integral part of mine operation, as manifestly no reasonably efficient coal mine under present-day conditions could be worked without these and numerous other functioning agencies or departments. Rock-dusting in some coal mines has taken its place as one of the main operating functions, and in many mines rock-dusting is assessed against operating costs, just as are ventilation, haulage, drainage, blasting, etc.; this is as it should be, and all nonanthracite coal mines should be required to rock-dust as routine daily operating procedure.

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While the entire operating personnel, including all officials and workers, certainly should partake actively in accident-prevention activities, up-and-coming mining organizations have for the past several years realized that "what's everybody's business is nobody's business", and that accident-prevention work must be placed in a specific department if accidents are actually to be prevented. Since real accomplishment in maintaining safe operation of mines depends largely on the safety department, it seems fair to take as the cost of accident-prevention work in a coal mine the costs due to this department and its activities, with the knowledge, however, that much safety work, the cost of which goes into the regular working accounts, is done by the operating departments, but that through safety of operation efficiency is increased and costs are lowered.

Table 7 gives data in connection with one study made on the cost of accident-prevention work; the data, however, are by no means as complete as desirable.

TABLE 7.- Cost of accident-prevention work

Item	Mine A	Mine B	Mine C	Mine D	Mine E	Mine F	Mine G
Salaries		$1,600.00			$9,000.00		(1/)
First-aid training and supplies		232.87			2,110.00		(1/)
Mine-rescue training		86.25			10.00		(1/)
First-aid contests					1,650.00		(1/)
Safety meetings					275.00	$0.00150	(1/)
Bulletin boards and posters		100.00	$690.00		125.00	.00025	(1/)
Bonuses and awards			25.00				
Protective clothing		50.00					
Cost of insurance per ton	$0.0208				.0275		
Cost of accident prevention per ton		.0028	.015	$0.013	.0194	.0020	$0.0125
Miscellaneous costs	60.00		75.00		1,554.50	.00025	
Total cost	2,967.51	2,079.12	16,500.00	10,000.00	13,174.00		7.500
Production, tons per year				750,000	2,560,030	287,000	

[1]Separate costs not given.

NOTE.- One company expends 2.6 mills per ton for accident prevention. Another company has an estimated cost of $4,500; production, 1,200,000 per year; cost 0.375 cent per ton. A coal company has a cost of 0.7 cent per ton, including salaries, safety meetings, and rock-dusting. Still another coal company, producing 1,441,695 tons per year, had (1932) a total cost of $3,717.76 or $0.0025 per ton.

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TABLE 7.- Cost of accident-prevention work - Continued

Item	Mine H	Mine I	Mine J	Mine K	Mine L	Mine M
Salaries		(1/)	(1/)			(1/)
First-aid training and supplies	(1/)	(1/)	(1/)	(1/)	(1/)	(1/)
Mine-rescue training			(1/)			
First-aid contests	(1/)		(1/)	(1/)		(1/)
Safety meetings	(1/)	(1/)			(1/)	
Bulletin boards and posters				(1/)		
Bonuses and awards					(1/)	
Protective clothing						
Cost of insurance per ton						
Cost of accident prevention per ton	$0.005	$0.007	$0.009	$0.003	$0.005	$0.004
Miscellaneous costs						
Total cost						
Production, tons per year	143,713	210,823	822,337	220,000	220,000	216,000

[1]Separate costs not given.

NOTE.- One company expends 2.6 mills per ton for accident prevention. Another company has an estimated cost of $4,500; production, 1,200,000 per year; cost 0.375 cent per ton. A coal company has a cost of 0.7 cent per ton, including salaries, safety meetings, and rock-dusting. Still another coal company, producing 1,441,695 tons per year, had (1932) a total cost of $3,717.76 or $0.0025 per ton.

One coal-mining company, with one of the best safety records in the history of coal mining in the United States, gave $1,350.00 as the cost of accident-prevention work in the production of about 220,000 tons of coal, or about 0.6 cent per ton. Another company produced about 1,440,000 tons of coal at a cost of $3,700.00 for its accident-prevention work, or about 0.25 cent per ton; the items included first-aid training and bandages, etc., safety bonuses, safety contests, wages and expenses of safety personnel, etc. Still another coal-mining company over a 4-year period produced about 7,500,000 tons of coal, and its records showed an average per-ton cost for its safety department (accident-prevention work) of 0.32 cent; this company shows very good safety accomplishment. Another coal-mining company with a better-than-average safety record produced about 5,200,000 tons of coal, and the books showed the cost of operating its safety department as $0.35 per $100 of pay roll. A coal mine with one of the outstanding safety records in coal mining in the United States placed the cost of its accident prevention work at 0.9 cent per ton on an output of slightly less than 300,000 tons of coal, the cost including salaries, bonuses, safety meetings, first-aid contests, and numerous small items. One coal-mining company, producing about 1,200,000 tons of coal, placed its safety-department expenditures at about $4,500, or about three eighths cent per ton. Another large producer of coal indicated that definite figures were not at hand but that an estimate of 0.75 to 1 cent per ton for accident-prevention work at its mine would be about right; another fairly large producer of coal with a good accident record placed an estimate of 0.25 cent per ton as the cost of its accident-prevention work, that is, its safety-department activities. One company with a production of 725,000 tons placed the cost of its safety work at 0.2 cent per ton, and for several years it has had an excell-

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ent safety record; this company reports that in 1927 the costs entering into accident occurrence average 8 to 10 cents per ton but that in 1934 these costs had been reduced to slightly over 2 cents per ton.

The average of the above costs for safety departments in coal mines, most of which have excellent safety performance, is about 0.75 cent per ton, and it seems conservative to use as the average cost of a well-functioning safety department 1 cent per ton of coal produced, although under some conditions the cost may be around or even in excess of 2 cents per ton. This average cost of accident-prevention work in and around coal mines, of course, does not cover such items of accident-prevention work as apply largely to ventilation, timbering, drainage, rock-dusting, haulage, etc., as these items are (and should be) chargeable against production or operating cost; but it can be stated confidently that for every cent devoted by these operating agencies to the forwarding of safety at least an equal cost advantage is secured in efficiency, and some mining organizations state that safety devices, methods, and practices put into effect by or through the operating personnel reduce cost as well as increase tonnage.

For the average mine the cost of the safety department and its activities should be about 1 cent per ton of coal in coal mines, or an average of not more than $1.00 per $100 of pay roll for all types of coal, metal, and nonmetallic mineral underground properties, but the cost for quarries and opencut mines should be considerably less. The cost includes the salaries of safety inspectors; the cost of posters, first-aid equipment, etc.; the expense of training all men in first-aid; and the financing of periodical safety meetings and possibly of a sectional first-aid contest annually. Since figures show that the safety department and its activities cost between about 0.5 cent and 1.5 cents per ton of coal mined and that 1 cent per ton is a fair average cost, these costs usually are less than $1.00 and are rarely as much as $1.50 per $100 of pay roll.

MINE-ACCIDENT COSTS WHERE EFFECTIVE SAFETY WORK IS DONE

The results of the work of an effective safety organization are not obtained readily, but some fairly definite data are at hand. A mine[17] in the Pittsburgh (Pa.) region, by perfecting a safety organization and giving it authority, reduced its compensation, medical, and hospitalization costs from 8 cents per ton of coal mined in 1930 to 0.73 cent per ton for compensation and 1.2 cents per ton for compensation, medical, and hospitalization costs in 1931. Another coal company in the same region, with a well-functioning safety organization and a good safety record, in the production of two thirds of a million tons of coal in 1931 had compensation cost of only 1.3 cents per ton; another company producing over 1,000,000 tons of coal in 1931 had a compensation cost of 1.73 cents per ton. One large producer of coal (with an annual output of about 10,000,000 tons) after having instituted a good safety organization reduced compensation, hospitalization, and medical cost from 4 cents per ton to 1.8 cents. These companies all have actively functioning safety organizations; several other companies operating in the same region without safety departments have compensation costs of 5 to 7 or more cents per ton.

Many coal mines now hold their compensation costs well under 1 cent per ton, and scores of coal, metal, and nonmetallic (both open pit and underground) mines now have compensation, hospitalization, and medical costs of less than 25 cents per $100 of pay roll; many mines have operated for a year or more,[18] in some instances 4, 5, or 6 years, without a lost-time accident, hence with compensation charges essentially nil.

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17 Ryan, J. T., Profits Through Reduction of Accidents: Min. Cong. Jour., vol. 18, no. 9, September 1932, p. 15.

18 Harrington, D., The Joseph A. Holmes Safety Association and Its Awards: Inf. Circ. 6831, Bureau of Mines, 1935, 100 pp.

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Well-planned, well-sustained safety organizations and campaigns have reduced unbelievably accident occurrence (frequency, severity, and costs) within the past 10 years and especially within the past 5 years. One company working both coal and metal mines in a recent 5-year period[19] reduced accident frequency 92 percent in its coal mines and 96 percent in its metal mines; a coal mine reduced accident frequency from 89.9 in 1926 to 12.65 in 1930 and accident severity from 10.81 in 1926 to 0.91 in 1930; a metal-mining company reduced accident frequency from 138.33 in 1923 to 5.44 in 1930, or 97.11 percent; a petroleum organization reduced accident frequency from 87.9 in 1926 to 3.3 in 1930; a surface metal mine reduced accident frequency from 121.3 and accident severity from 10.1 in 1922 to 8.6 and 0.2, respectively, in 1931; as a result of a safety drive a company operating several quarries, a coal mine, and a manufacturing plant reduced lost-time accidents from 307 in 1927 to 16 in 1931, or practically 95 percent; a large-capacity coal-mining company reduced accident frequency from 340.15 in 1929 to 74.04 in 1933 and accident severity from 43.74 in 1929 to 2.09 in 1933; a petroleum company decreased frequency from 22.37 in 1927 to 7.67 in 1932, or practically 67 percent, and reduced severity from 4.81 in 1927 to 0.26 in 1932, or about 95 percent; from 1930 to 1933 a coal mine reduced the number of lost-time accidents 92.8 percent, accident frequency 89.2 percent, accident severity 97.2 percent and cost of accidents 91.3 percent; a large coal-mining company operating several mines reduced accident frequency 75 percent from 1929 to 1933; a metal-mining company operating mines, mills, smelters, etc., reduced accident frequency from 188.25 in 1923 to 1.47 in 1933, and during this period its underground mine worked considerably over a year without a lost-time accident; and a similar organization reduced frequency from 64.41 in 1929 to 5.16 in 1933 and accident severity from 10.96 in 1929 to 0.077 in 1933.

From the foregoing and numerous similar records at hand it appears that reducing accident occurrence (including frequency, severity, and cost) as much as 90 percent within a few years through well-directed accident-prevention activities in the mining and allied industries is by no means unusual, and this would appear to warrant a statement that at least 75 percent of the accidents in and around our mines and mining plants can be prevented. That this is not an absurd assumption or one not feasible of accomplishment is substantiated, at least somewhat, by the following statement taken from an interesting publication entitled "Tendencies in Workmen's Compensation", issued by the United States Chamber of Commerce:

> It is not uncommon to find industrial plants over a short period of years reducing accidents from 75 to 90 percent, and there are many plants which have records of several million man-hours without a lost-time accident. * * * The cement industry, which leads all others in point of accident reduction, has made a remarkable record. Out of 150 cement plants, located in all parts of the United States and Canada, 45 finished a recent year without a single lost-time accident among their thousands of employees.

This pamphlet also contains the following rather significant statement:

> Workmen's compensation has been a constant factor in stimulating accident prevention work.

ACCIDENT COSTS AND SAFETY SAVINGS FOR THE EMPLOYER

It thus appears that the present-day cost of accidents in coal mining averages about 20 cents per ton produced, that many progressive mining companies in a very few years (certainly within 5 years) have reduced their accidents as much as 90 percent and some by 95 or more percent, and that by well-directed effort at least 75 percent of the present-day rate of

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19 See footnote 18.

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accident occurrence in and around mines can be eliminated; hence it can be stated conservatively that accidents should cost our coal mines not more than 5 cents per ton instead of approximately 20 cents as at present, and this means that real mine safety work may save about 15 cents per ton. On the 1934 coal output of about 415,000,000 tons for the United States, this would amount to a dollars-and-cents saving of nearly $62,000,000, certainly a handsome "dividend" readily available to our coal-mine operators whenever they can be induced to "get down to brass tacks" in connection with safety in the operation of the coal mines of the United States.

If the economic phase of safety in mining is viewed on the basis of percentage of production cost of the country's mineral output due to accidents it seems reasonable to believe that at least 10 percent of the cost of production of raw minerals is due in one manner or another to accident occurrence. Domestic raw mineral production in 1934 is supposed to have had a value of about $2,500,000,000, and if 10 percent of this was chargeable to accidents the mineral-production accident bill for 1934 was about $250,000,000; if this can be reduced 75 percent (and there is the best of reasons to believe that it can) the saving would amount to $187,500,000. This sizable dividend is available to the mining industry of the United States whenever the leaders in that industry finally bring themselves to exert the personal effort and financial outlay necessary for real safety achievement. A relatively light financial outlay would bring about this desirable result, as the mining companies with outstanding safety records indicate that maintenance of an effective safety organization and plan requires an outlay considerably less than 1 percent of the cost of production, usually being less than 1 cent per ton in coal mining and less than $1.00 per $100 of pay roll in other types of mining.

ACCIDENT COSTS AND SAFETY SAVINGS FOR THE WORKER

Practically all of the foregoing discussion on economic aspects of accident occurrence in mining has been confined to the effect on the owner or operator, but the effects on the worker, both humanitarian and economic, are far more vital than those on the employer. No estimate can ever be made as to the cost of the enormous amount of human suffering and misery involved in the 2,000 to 3,000 fatalities and 100,000 to 150,000 or more nonfatal accidents that have occurred annually in and around mining operations in this country, and only rough approximations can be made as to the dollars-and-cents cost of these accidents to the worker and those dependent on him.

It has already been indicated that the slow but definite reduction in fatality rate in domestic coal mines in the past 24 years has very probably saved about 25,500 lives and at least 1,275,000 nonfatal coal-mining accidents. The average age of the coal miner who is killed is about 35 years, and under normal conditions he should earn at least $1,000 per year and have a wage-earning life expectancy of 20 years; hence in that period he would receive $20,000 for his services. Therefore, the saving of the lives of about 25,500 coal-mine workers in the past 24 years has prevented a financial loss to them and their families of around $510,000,000.

In the prevention of 1,275,000 nonfatal accidents during this 24-year period the coal miners and their friends and families have been saved not only a vast amount of suffering and misery but also enormous financial loss. It is now thought that the average cost of a nonfatal accident to the employer is about $300, and of this about two thirds or three fourths is the amount paid to the injured person. If the average amount paid to the injured man for nonfatal compensable injuries is $200, then the amount received by injured persons for 1,275,000 of these injuries would be $255,000,000. However, investigations now indicate that for every dollar received in compensation for injuries the injured man suffers a loss of at

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least $3 (and some investigators place the loss as high as $5) in loss of wages and other losses and costs. Hence, if $3 or the lowest figure is accepted, the workers have been saved $765,000,000 in the nonfatal compensable accidents which it is estimated have been prevented by greater safety in coal mines of this country during the past 24 years.

Unquestionably, there have been additional enormous savings to coal-mine workers in the prevention of millions of noncompensable nonfatal injuries during the past 24 years, and even if these are omitted the savings to coal-mine workers by the prevention of fatal and nonfatal compensable injuries for these 24 years totals $1,275,000,000, or more than $73,-000,000 per year. If to this total were added the very material savings through prevention of noncompensable, nonfatal accidents (the financial burden of which falls more heavily on the injured person than on the employer) doubtless our coal-mine workers have benefitted financially at least $100,000,000 annually by the greater safety in coal-mine operation since 1910.

Similar savings have been made by workers in the various other branches of the mining and allied industries, and it appears from known facts that the annual dollars-and-cents savings to mine workers (coal, metal, nonmetallic, etc.) in the greater safety of mine operation now as against that 25 years ago is at least $200,000,000 per year, or about $200 per year for every one of the approximately 1,000,000 persons now engaged in the various types of mining. Certainly the mine worker has a much more vital interest in the forwarding of safety in mine operation than has the operator, because the worker must endure the physical pain and suffering from accidents, also his individual financial losses from accidents and gain through their prevention are far greater than the similar gains or losses of the employer.

CONCLUSION

Instead of being the "fad" which far too many of those engaged in mining have always considered safety effort or safety "preachments", the prevention of accidents now is becoming known as one of the most vital economic features in the production of our mineral products, and there is reason to believe that few if any phases of mining have greater possibilities in relatively quick and effective reduction of production costs and increase in working efficiency than have the installation and strict maintenance of an up-to-date safety procedure in and around our mines and mining plants.

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